

WHAT IS CLAIMED IS

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1. A distributed Bragg reflector,
comprising:

a first semiconductor layer having a first,
larger refractive index;

10 a second semiconductor layer having a
second, lower refractive index,

said first and second semiconductor layers
being stacked alternately,

a material layer having a refractive index
15 intermediate between said first and second refractive
indices,

said distributed Bragg reflector being
tuned to a wavelength of 1.1 μm or longer,

wherein there is provided a material layer
20 having a refractive index intermediate between said
first refractive index and said second refractive
index,

said material layer having a thickness
equal to or larger than 5 nm but equal to or smaller
25 than 50 nm.

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2. A distributed Bragg reflector as claimed
in claim 1, wherein said material layer has a
thickness equal to or larger than 20 nm.

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3. A distributed Bragg reflector as claimed
in claim 1, wherein said material layer has a
10 thickness equal to or larger than 30 nm.

15 4. A distributed Bragg reflector as claimed
in claim 2, wherein said first and second
semiconductor layers are formed of any of AlAs, GaAs
and AlGaAs, and wherein there is a difference of Al
content of less than 80% between said first
20 semiconductor layer and said second semiconductor
layer.

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5. A distributed Bragg reflector as claimed
in claim 3, wherein said first semiconductor layer
and said second semiconductor layer are formed of any
of AlAs, GaAs and AlGaAs, and wherein there is a
5 difference of Al content of 80% or more between said
first semiconductor layer and said second
semiconductor layer.

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6. A distributed Bragg reflector,
comprising:

a first semiconductor layer having a first,
15 larger refractive index;

a second semiconductor layer having a
second, lower refractive index,

said first and second semiconductor layers
being stacked alternately,

20 a material layer having a refractive index
intermediate between said first and second refractive
indices,

said distributed Bragg reflector being
tuned to a wavelength of 1.1 μm or longer,

25 wherein there is provided a material layer

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having a refractive index intermediate between said first refractive index and said second refractive index,

said material layer having a thickness
5 smaller than $(50\lambda-15)$ [nm] where λ is a tuned wavelength of the distributed Bragg reflector.

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7. A distributed Bragg reflector as claimed in claim 6, wherein said material layer has a thickness of 20 nm or more.

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8. A distributed Bragg reflector as claimed in claim 6, wherein said material layer has a
20 thickness of 30 nm or more.

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9. A distributed Bragg reflector,

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10. A distributed Bragg reflector as
claimed in claim 9, wherein said intermediate layer
changes said valence band energy continuously and
gradually from said first semiconductor layer to said
5 second semiconductor layer.

10 11. A distributed Bragg reflector as
claimed in claim 9, wherein said intermediate layer
changes said valence band energy stepwise from said
first semiconductor layer to said second
semiconductor layer.

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12. A distributed Bragg reflector as
20 claimed in claim 9, wherein said intermediate layer
comprises a layer in which said valence band energy
changes continuously and a layer in which said
valence band energy changes stepwise.

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13. A distributed Bragg reflector as
claimed in claim 9, wherein said first and second
layers have respective first and second thicknesses,
such that said first thickness is smaller than said
5 second thickness.

10 14. A distributed Bragg reflector as
claimed in claim 9, wherein there is a stepped change
of valence band energy at an interface between said
first semiconductor layer and said material layer.

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15. A distributed Bragg reflector as
claimed in claim 9, wherein said first and second
20 semiconductor layers comprise a material of AlGaAs
system.

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16. A distributed Bragg reflector as claimed in claim 9, wherein said first and second semiconductor layers comprise a material of AlGaAsP system.

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17. A distributed Bragg reflector as
10 claimed in claim 9, wherein said first and second semiconductor layers and said intermediate layer have a carrier density of $5 \times 10^{17} \text{cm}^{-3} - 2 \times 10^{18} \text{cm}^{-3}$, and wherein said intermediate layer has a thickness in the range of 5 - 40 nm, and wherein said intermediate
15 layer is characterized by an average change rate of Al content in the range of 0.02 - 0.05 nm⁻¹.

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18. A surface-emission laser diode,
comprising:

an active layer; and

a resonator cooperating with said active
25 layer, said active layer comprising upper and lower

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reflectors disposed above and below said active layer,
at least one of said upper and lower
reflectors comprising a distributed Bragg reflector,
comprising:

5 a first semiconductor layer having a first,
larger refractive index;

a second semiconductor layer having a
second, lower refractive index,

said first and second semiconductor layers
10 being stacked alternately,

a material layer having a refractive index
intermediate between said first and second refractive
indices,

said distributed Bragg reflector being
15 tuned to a wavelength of $1.1 \mu\text{m}$ or longer,

wherein there is provided a material layer
having a refractive index intermediate between said
first refractive index and said second refractive
index,

20 said material layer having a thickness
equal to or larger than 5 nm but equal to or smaller
than 50 nm.

19. A surface-emission laser diode as claimed in claim 18, wherein said material layer has a thickness equal to or larger than 20 nm.

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20. A surface-emission laser diode as claimed in claim 18, wherein said material layer has a thickness equal to or larger than 30 nm.

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21. A surface-emission laser diode as claimed in claim 19, wherein said first and second semiconductor layers are formed of any of AlAs, GaAs and AlGaAs, and wherein there is a difference of Al content of less than 80% between said first semiconductor layer and said second semiconductor layer.

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22. A surface-emission laser diode as
claimed in claim 20, wherein said first semiconductor
layer and said second semiconductor layer are formed
of any of AlAs, GaAs and AlGaAs, and wherein there is
5 a difference of Al content of 80% or more between
said first semiconductor layer and said second
semiconductor layer.

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23. A surface-emission laser diode as
claimed in claim 18, wherein said active layer is
formed of any of a GaNAs layer, a GaInAs layer, a
15 GaInNAs layer, a GaAsSb layer, a GaInAsSb layer, and
a GaInNAsSb layer.

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24. A surface-emission laser diode,
comprising:

an active layer; and

a resonator cooperating with said active
layer, said active layer comprising upper and lower
25 reflectors disposed above and below said active layer,

at least one of said upper and lower reflectors comprising a distributed Bragg reflector, comprising:

a first semiconductor layer having a first,
5 larger refractive index;

a second semiconductor layer having a second, lower refractive index,

said first and second semiconductor layers being stacked alternately,

10 a material layer having a refractive index intermediate between said first and second refractive indices,

said distributed Bragg reflector being tuned to a wavelength of $1.1 \mu\text{m}$ or longer,

15 wherein there is provided a material layer having a refractive index intermediate between said first refractive index and said second refractive index,

said material layer having a thickness
20 smaller than $(50\lambda - 15)$ [nm] where λ is a tuned wavelength of the distributed Bragg reflector.

25. A surface-emission laser diode as
claimed in claim 24, wherein said material layer has
a thickness of 20 nm or more.

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26. A surface-emission laser diode as
claimed in claim 24, wherein said material layer has
10 a thickness of 30 nm or more.

15 27. A surface-emission laser diode as
claimed in claim 24, wherein said active layer is
formed of any of a GaNAs layer, a GaInAs layer, a
GaInNAs layer, a GaAsSb layer, a GaInAsSb layer, and
a GaInNAsSb layer.

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28. A surface-emission laser diode,
25 comprising:

an active layer; and

a resonator cooperating with said active layer, said active layer comprising upper and lower reflectors disposed above and below said active layer,

5 at least one of said upper and lower reflectors comprising a distributed Bragg reflector, comprising:

a first semiconductor layer having a first, smaller bandgap;

10 a second semiconductor layer having a second, larger bandgap,

said first and second semiconductor layers being stacked alternately,

a material layer having a bandgap
15 intermediate between said first and second bandgaps, provided between said first and second semiconductor layer,

said material layer changing a valence band energy thereof in a thickness direction from said
20 first semiconductor layer to said second semiconductor layer,

said material layer comprising a first layer adjacent to said first semiconductor layer and a second layer adjacent to said second semiconductor
25 layer,

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said first layer and second layer having first and second rates of compositional change such that said first rate being larger than said second rate.

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29. A surface-emission laser diode as
10 claimed in claim 28, wherein said intermediate layer changes said valence band energy continuously and gradually from said first semiconductor layer to said second semiconductor layer.

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30. A surface-emission laser diode as
claimed in claim 28, wherein said intermediate layer
20 changes said valence band energy stepwise from said first semiconductor layer to said second semiconductor layer.

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31. A surface-emission laser diode as
claimed in claim 28, wherein said intermediate layer
comprises a layer in which said valence band energy
changes continuously and a layer in which said
5 valence band energy changes stepwise.

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32. A surface-emission laser diode as
claimed in claim 28, wherein said first and second
layers have respective first and second thicknesses,
such that said first thickness is smaller than said
15 second thickness.

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33. A surface-emission laser diode as
claimed in claim 28, wherein there is a stepped
change of valence band energy at an interface between
said first semiconductor layer and said material
layer.

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34. A surface-emission laser diode as claimed in claim 28, wherein said first and second semiconductor layers comprise a material of AlGaAs system.

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35. A surface-emission laser diode as claimed in claim 28, wherein said first and second semiconductor layers comprise a material of AlGaAsP system.

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36. A surface-emission laser diode as claimed in claim 28, wherein said first and second semiconductor layers and said intermediate layer have a carrier density of $5 \times 10^{17} \text{cm}^{-3} - 2 \times 10^{18} \text{cm}^{-3}$, and wherein said intermediate layer has a thickness in the range of 5 - 40 nm, and wherein said intermediate layer is characterized by an average change rate of Al content in the range of 0.02 - 0.05 nm⁻¹.

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37. A laser diode array, comprising:
- 5 a substrate; and
- a plurality of surface-emission laser diodes formed commonly on said substrate, each of said plurality of surface-emission laser diodes comprising:
- 10 an active layer; and
- a resonator cooperating with said active layer, said active layer comprising upper and lower reflectors disposed above and below said active layer, at least one of said upper and lower
- 15 reflectors comprising a distributed Bragg reflector, comprising:
- a first semiconductor layer having a first, larger refractive index;
- a second semiconductor layer having a
- 20 second, lower refractive index,
- said first and second semiconductor layers being stacked alternately,
- a material layer having a refractive index intermediate between said first and second refractive
- 25 indices,

said distributed Bragg reflector being
tuned to a wavelength of $1.1 \mu\text{m}$ or longer,

wherein there is provided a material layer
having a refractive index intermediate between said
5 first refractive index and said second refractive
index,

said material layer having a thickness
equal to or larger than 5 nm but equal to or smaller
than 50 nm.

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38. A laser diode array, comprising:
15 a substrate; and
a plurality of surface-emission laser
diodes formed commonly on said substrate, each of
said surface emission laser diodes comprising:
an active layer; and
20 a resonator cooperating with said active
layer, said active layer comprising upper and lower
reflectors disposed above and below said active layer,
at least one of said upper and lower
reflectors comprising a distributed Bragg reflector,
25 comprising:

a first semiconductor layer having a first, larger refractive index;

a second semiconductor layer having a second, lower refractive index,

5 said first and second semiconductor layers being stacked alternately,

a material layer having a refractive index intermediate between said first and second refractive indices,

10 said distributed Bragg reflector being tuned to a wavelength of $1.1 \mu\text{m}$ or longer,

 wherein there is provided a material layer having a refractive index intermediate between said first refractive index and said second refractive
15 index,

 said material layer having a thickness smaller than $(50\lambda - 15)$ [nm] where λ is a tuned wavelength of the distributed Bragg reflector.

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39. A surface-emission laser diode array, comprising:

25 a substrate; and

a plurality of laser diodes, each of said surface-emission laser diodes, comprising:

an active layer; and

a resonator cooperating with said active
5 layer, said active layer comprising upper and lower reflectors disposed above and below said active layer, at least one of said upper and lower reflectors comprising a distributed Bragg reflector, comprising:

10 a first semiconductor layer having a first, smaller bandgap;

a second semiconductor layer having a second, larger bandgap,

said first and second semiconductor layers
15 being stacked alternately,

a material layer having a bandgap intermediate between said first and second bandgaps, provided between said first and second semiconductor layer,

20 said material layer changing a valence band energy thereof in a thickness direction from said first semiconductor layer to said second semiconductor layer,

said material layer comprising a first
25 layer adjacent to said first semiconductor layer and

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a second layer adjacent to said second semiconductor layer,

said first layer and second layer having first and second rates of compositional change such that said first rate being larger than said second rate.

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40. An optical interconnection system, comprising:

a surface-emission laser diode; and
an optical transmission path coupled
15 optically to said surface-emission laser diode,
said surface-emission laser diode
comprising:
an active layer; and
a resonator cooperating with said active
20 layer, said active layer comprising upper and lower
reflectors disposed above and below said active layer,
at least one of said upper and lower
reflectors comprising a distributed Bragg reflector,
comprising:
25 a first semiconductor layer having a first,

larger refractive index;

a second semiconductor layer having a
second, lower refractive index,

said first and second semiconductor layers
5 being stacked alternately,

a material layer having a refractive index
intermediate between said first and second refractive
indices,

said distributed Bragg reflector being
10 tuned to a wavelength of $1.1 \mu\text{m}$ or longer,

wherein there is provided a material layer
having a refractive index intermediate between said
first refractive index and said second refractive
index,

15 said material layer having a thickness
equal to or larger than 5 nm but equal to or smaller
than 50 nm.

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41. An optical interconnection system,
comprising:

a surface-emission laser diode; and
25 an optical transmission path coupled

optically to said surface-emission laser diode,
said surface-emission laser diode
comprising:

an active layer; and

5 a resonator cooperating with said active
layer, said active layer comprising upper and lower
reflectors disposed above and below said active layer,
at least one of said upper and lower
reflectors comprising a distributed Bragg reflector,
10 comprising:

a first semiconductor layer having a first,
larger refractive index;

a second semiconductor layer having a
second, lower refractive index,

15 said first and second semiconductor layers
being stacked alternately,

a material layer having a refractive index
intermediate between said first and second refractive
indices,

20 said distributed Bragg reflector being
tuned to a wavelength of $1.1 \mu\text{m}$ or longer,

wherein there is provided a material layer
having a refractive index intermediate between said
first refractive index and said second refractive
25 index,

said material layer having a thickness smaller than $(50\lambda-15)$ [nm] where λ is a tuned wavelength of the distributed Bragg reflector.

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42. An optical interconnection system, comprising:

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a surface-emission laser diode; and
an optical transmission path coupled optically to said surface-emission laser diode,
said surface-emission laser diode comprising:

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an active layer; and
a resonator cooperating with said active layer, said active layer comprising upper and lower reflectors disposed above and below said active layer,
at least one of said upper and lower
20 reflectors comprising a distributed Bragg reflector,
comprising:

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a first semiconductor layer having a first, smaller bandgap;

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a second semiconductor layer having a second, larger bandgap,

said first and second semiconductor layers
being stacked alternately,

a material layer having a bandgap
intermediate between said first and second bandgaps,
5 provided between said first and second semiconductor
layer,

said material layer changing a valence band
energy thereof in a thickness direction from said
first semiconductor layer to said second
10 semiconductor layer,

said material layer comprising a first
layer adjacent to said first semiconductor layer and
a second layer adjacent to said second semiconductor
layer,

15 said first layer and second layer having
first and second rates of compositional change such
that said first rate being larger than said second
rate.

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43. An optical interconnection system,
comprising:

25 a surface-emission laser diode array

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comprising a substrate and a plurality of surface-emission laser diodes provided commonly on said substrate; and

an optical transmission path coupled
5 optically to each of said plurality of surface-emission laser diodes,

each of said plurality of surface-emission laser diodes comprising:

an active layer; and
10 a resonator cooperating with said active layer, said active layer comprising upper and lower reflectors disposed above and below said active layer, at least one of said upper and lower reflectors comprising a distributed Bragg reflector,
15 comprising:

a first semiconductor layer having a first, larger refractive index;

a second semiconductor layer having a second, lower refractive index,

20 said first and second semiconductor layers being stacked alternately,

a material layer having a refractive index intermediate between said first and second refractive indices,

25 said distributed Bragg reflector being

tuned to a wavelength of 1.1 μm or longer,

wherein there is provided a material layer
having a refractive index intermediate between said
first refractive index and said second refractive
5 index,

said material layer having a thickness
equal to or larger than 5 nm but equal to or smaller
than 50 nm.

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44. An optical interconnection system,
comprising:

15 a surface-emission laser diode array
comprising a substrate and a plurality of surface-
emission laser diodes formed commonly on said
substrate; and

an optical transmission path coupled
20 optically to each of said plurality of surface-
emission laser diodes,

each of said surface-emission laser diodes
comprising:

an active layer; and
25 a resonator cooperating with said active

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layer, said active layer comprising upper and lower reflectors disposed above and below said active layer, at least one of said upper and lower reflectors comprising a distributed Bragg reflector,

5 comprising:

a first semiconductor layer having a first, larger refractive index;

a second semiconductor layer having a second, lower refractive index,

10 said first and second semiconductor layers being stacked alternately,

a material layer having a refractive index intermediate between said first and second refractive indices,

15 said distributed Bragg reflector being tuned to a wavelength of $1.1 \mu\text{m}$ or longer,

wherein there is provided a material layer having a refractive index intermediate between said first refractive index and said second refractive index,

20 said material layer having a thickness smaller than $(50\lambda - 15)$ [nm] where λ is a tuned wavelength of the distributed Bragg reflector.

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45. An optical interconnection system,
comprising:

a surface-emission laser diode array
comprising a plurality of surface-emission laser
5 diodes; and

an optical transmission path coupled
optically to each of said plurality of surface-
emission laser diodes,

each of said surface-emission laser diodes
10 comprising:

an active layer; and

a resonator cooperating with said active
layer, said active layer comprising upper and lower
reflectors disposed above and below said active layer,

15 at least one of said upper and lower
reflectors comprising a distributed Bragg reflector,
comprising:

a first semiconductor layer having a first,
smaller bandgap;

20 a second semiconductor layer having a
second, larger bandgap,

said first and second semiconductor layers
being stacked alternately,

a material layer having a bandgap
25 intermediate between said first and second bandgaps,

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provided between said first and second semiconductor layer,

said material layer changing a valence band energy thereof in a thickness direction from said
5 first semiconductor layer to said second semiconductor layer,

said material layer comprising a first layer adjacent to said first semiconductor layer and a second layer adjacent to said second semiconductor
10 layer,

said first layer and second layer having first and second rates of compositional change such that said first rate being larger than said second rate.

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46. An optical telecommunication system,
20 comprising:

a surface-emission laser diode; and
an optical transmission path coupled optically to said surface-emission laser diode,
said surface-emission laser diode

25 comprising:

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an active layer; and

a resonator cooperating with said active layer, said active layer comprising upper and lower reflectors disposed above and below said active layer,

5 at least one of said upper and lower reflectors comprising a distributed Bragg reflector, comprising:

a first semiconductor layer having a first, larger refractive index;

10 a second semiconductor layer having a second, lower refractive index,

said first and second semiconductor layers being stacked alternately,

15 a material layer having a refractive index intermediate between said first and second refractive indices,

said distributed Bragg reflector being tuned to a wavelength of $1.1 \mu\text{m}$ or longer,

20 wherein there is provided a material layer having a refractive index intermediate between said first refractive index and said second refractive index,

said material layer having a thickness equal to or larger than 5 nm but equal to or smaller
25 than 50 nm.

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a surface-emission laser diode; and
an optical transmission path coupled
optically to said surface-emission laser diode,
said surface-emission laser diode

an active layer; and

15 a first semiconductor layer having a first,
larger refractive index;

said first and second semiconductor layers
20 being stacked alternately,

said distributed Bragg reflector being
25 tuned to a wavelength of 1.1 μm or longer,

wherein there is provided a material layer having a refractive index intermediate between said first refractive index and said second refractive index,

5 said material layer having a thickness smaller than $(50\lambda - 15)$ [nm] where λ is a tuned wavelength of the distributed Bragg reflector.

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48. An optical telecommunication system, comprising:

 a surface-emission laser diode; and
15 an optical transmission path coupled optically to said surface-emission laser diode, said surface-emission laser diode

comprising:

 an active layer; and
20 a resonator cooperating with said active layer, said active layer comprising upper and lower reflectors disposed above and below said active layer, at least one of said upper and lower reflectors comprising a distributed Bragg reflector,
25 comprising:

a first semiconductor layer having a first, smaller bandgap;

a second semiconductor layer having a second, larger bandgap,

5 said first and second semiconductor layers being stacked alternately,

 a material layer having a bandgap intermediate between said first and second bandgaps, provided between said first and second semiconductor
10 layer,

 said material layer changing a valence band energy thereof in a thickness direction from said first semiconductor layer to said second semiconductor layer,

15 said material layer comprising a first layer adjacent to said first semiconductor layer and a second layer adjacent to said second semiconductor layer,

 said first layer and second layer having
20 first and second rates of compositional change such that said first rate being larger than said second rate.

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49. An optical telecommunication system,
comprising:

a surface-emission laser diode array
5 comprising a substrate and a plurality of surface-
emission laser diodes provided commonly on said
substrate; and

an optical transmission path coupled
optically to each of said plurality of surface-
10 emission laser diodes,

each of said plurality of surface-emission
laser diodes comprising:

an active layer; and

a resonator cooperating with said active
15 layer, said active layer comprising upper and lower
reflectors disposed above and below said active layer,
at least one of said upper and lower
reflectors comprising a distributed Bragg reflector,
comprising:

20 a first semiconductor layer having a first,
larger refractive index;

a second semiconductor layer having a
second, lower refractive index,

said first and second semiconductor layers
25 being stacked alternately,

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a material layer having a refractive index intermediate between said first and second refractive indices,

said distributed Bragg reflector being
5 tuned to a wavelength of $1.1 \mu\text{m}$ or longer,

wherein there is provided a material layer having a refractive index intermediate between said first refractive index and said second refractive index,

10 said material layer having a thickness equal to or larger than 5 nm but equal to or smaller than 50 nm.

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50. An optical telecommunication system, comprising:

a surface-emission laser diode array
20 comprising a substrate and a plurality of surface-emission laser diodes formed commonly on said substrate; and

an optical transmission path coupled optically to each of said plurality of surface-
25 emission laser diodes,

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each of said surface-emission laser diodes
comprising:

an active layer; and

a resonator cooperating with said active
5 layer, said active layer comprising upper and lower
reflectors disposed above and below said active layer,
at least one of said upper and lower
reflectors comprising a distributed Bragg reflector,
comprising:

10 a first semiconductor layer having a first,
larger refractive index;

a second semiconductor layer having a
second, lower refractive index,

said first and second semiconductor layers
15 being stacked alternately,

a material layer having a refractive index
intermediate between said first and second refractive
indices,

said distributed Bragg reflector being
20 tuned to a wavelength of 1.1 μm or longer,

wherein there is provided a material layer
having a refractive index intermediate between said
first refractive index and said second refractive
index,

25 said material layer having a thickness

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smaller than $(50\lambda-15)$ [nm] where λ is a tuned wavelength of the distributed Bragg reflector.

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51..An optical telecommunication system,
comprising:

a surface-emission laser diode array
10 comprising a plurality of surface-emission laser
diodes; and

an optical transmission path coupled
optically to each of said plurality of surface-
emission laser diodes,

15 each of said surface-emission laser diodes
comprising:

an active layer; and

a resonator cooperating with said active
layer, said active layer comprising upper and lower
20 reflectors disposed above and below said active layer,
at least one of said upper and lower
reflectors comprising a distributed Bragg reflector,
comprising:

a first semiconductor layer having a first,
25 smaller bandgap;

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a second semiconductor layer having a
second, larger bandgap,

said first and second semiconductor layers
being stacked alternately,

5 a material layer having a bandgap
intermediate between said first and second bandgaps,
provided between said first and second semiconductor
layer,

said material layer changing a valence band
10 energy thereof in a thickness direction from said
first semiconductor layer to said second
semiconductor layer,

said material layer comprising a first
layer adjacent to said first semiconductor layer and
15 a second layer adjacent to said second semiconductor
layer,

said first layer and second layer having
first and second rates of compositional change such
that said first rate being larger than said second
20 rate.

25 52. An optical transmission/reception

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system, comprising:

an optical source formed of a surface-emission laser diode device, said surface-emission laser diode comprising: an active layer of any of a layer containing Ga, In, N and As as major constituent elements thereof and a layer containing Ga, In and As as major constituent elements thereof, said active layer producing optical radiation with a laser oscillation wavelength of $1.1 - 1.7 \mu\text{m}$; and a cavity structure comprising a pair of reflectors provided above and below said active layer, each of said reflectors forming a semiconductor distributed Bragg reflector reflecting optical radiation having a wavelength of $1.1 \mu\text{m}$ or more and comprising an alternate and repetitive stacking of a first material layer of $\text{Al}_x\text{Ga}_{1-x}\text{As}$ ($0 < x \leq 1$) and a second material layer of $\text{Al}_y\text{Ga}_{1-y}\text{As}$ ($0 \leq y < x \leq 1$), wherein there is provided a hetero spike buffer layer between said first material layer and said second material layer, said hetero spike buffer layer having a refractive index intermediate between a refractive index of said first material layer and a refractive index of said second material layer, said hetero spike buffer layer having a composition represented as $\text{Al}_z\text{Ga}_{1-z}\text{As}$ ($0 \leq y < z < x \leq 1$) and a thickness of 20 - 50 nm;

an optical fiber transmission path having
an end coupled optically to said optical source; and
a photodetection unit coupled to the other
end of said optical fiber transmission path,

5 said optical fiber transmission path being
bent between a point A, in which said optical source
is provided, and a point B, in which said
photodetection unit is provided, such that there is
no localized angle formed in said optical fiber
10 transmission path.

15 53. An optical transmission/reception
system, comprising:

an optical source formed of a surface-
emission laser diode device, said surface-emission
laser diode comprising: an active layer of any of a
20 layer containing Ga, In, N and As as major
constituent elements thereof and a layer containing
Ga, In and As as major constituent elements thereof,
said active layer producing optical radiation with a
laser oscillation wavelength of 1.1 - 1.7 μm ; and a
25 cavity structure comprising a pair of reflectors

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provided above and below said active layer, each of
said reflectors forming a semiconductor distributed
Bragg reflector reflecting optical radiation having a
wavelength of $1.1\mu\text{m}$ or more and comprising an
5 alternate and repetitive stacking of a first material
layer of $\text{Al}_x\text{Ga}_{1-x}\text{As}$ ($0 < x \leq 1$) and a second material
layer of $\text{Al}_y\text{Ga}_{1-y}\text{As}$ ($0 \leq y < x \leq 1$), wherein there is
provided a hetero spike buffer layer between said
first material layer and said second material layer,
10 said hetero spike buffer layer having a refractive
index intermediate between a refractive index of said
first material layer and a refractive index of said
second material layer, said hetero spike buffer layer
having a composition represented as $\text{Al}_z\text{Ga}_{1-z}\text{As}$ ($0 \leq$
15 $y < z < x \leq 1$) and a thickness of 20 - 50 nm;

an optical fiber transmission path having
an end coupled to said optical source;

a photodetection unit coupled to another
end of said optical fiber transmission path; and

20 a mirror provided between a point A, in
which said optical source is provided, and a point B,
in which said photodetection unit is provided, said
mirror changing a direction of propagation of an
optical signal transmitted through said optical fiber
25 transmission path.

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5 54. An optical transmission/reception
system for use in an apparatus, comprising:
an apparatus body;
a surface-emission laser diode device
provided in said apparatus body as a laser optical
10 source, said laser optical source producing an
optical signal;
a photodetection unit provided in said
apparatus body, said photodetection unit receiving
said optical signal;
15 a cover member covering a light emitting
part of said laser optical source; and
another cover member covering a
photodetection part of said photodetection unit,
said surface-emission laser diode
20 comprising: an active layer of any of a layer
containing Ga, In, N and As as major constituent
elements thereof and a layer containing Ga, In and As
as major constituent elements thereof, said active
layer producing optical radiation with a laser
25 oscillation wavelength of 1.1 - 1.7 μm ; and a cavity

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structure comprising a pair of reflectors provided above and below said active layer, each of said reflectors forming a semiconductor distributed Bragg reflector reflecting optical radiation having a wavelength of $1.1\mu\text{m}$ or more and comprising an alternate and repetitive stacking of a first material layer of $\text{Al}_x\text{Ga}_{1-x}\text{As}$ ($0 < x \leq 1$) and a second material layer of $\text{Al}_y\text{Ga}_{1-y}\text{As}$ ($0 \leq y < x \leq 1$), wherein there is provided a hetero spike buffer layer between said first material layer and said second material layer, said hetero spike buffer layer having a refractive index intermediate between a refractive index of said first material layer and a refractive index of said second material layer, said hetero spike buffer layer having a composition represented as $\text{Al}_z\text{Ga}_{1-z}\text{As}$ ($0 \leq y < z < x \leq 1$) and a thickness of 20 - 50 nm.

20

55. An optical telecommunication system, comprising:

a laser diode;

a first optical fiber coupled optically to

25 said laser diode, said first optical fiber being

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injected with a laser beam produced by said laser diode;

a second optical fiber coupled optically to said first optical fiber, said second optical fiber
5 being injected with an optical signal transmitted through said first optical fiber;

a third optical fiber coupled optically to said second optical fiber, said third optical fiber being injected with an optical signal transmitted
10 through said second optical fiber; and

a photodetector coupled optically to said third optical fiber, said photodetector detecting an optical signal transmitted through said third optical fiber,

15 said laser diode comprising a surface-emission laser diode chip and comprising: an active layer of any of a layer containing Ga, In, N and As as major constituent elements thereof and a layer containing Ga, In and As as major constituent
20 elements thereof, said active layer producing optical radiation with a laser oscillation wavelength of 1.1 - 1.7 μm ; and a cavity structure comprising a pair of reflectors provided above and below said active layer, each of said reflectors forming a
25 semiconductor distributed Bragg reflector reflecting

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optical radiation having a wavelength of $1.1\mu\text{m}$ or more and comprising an alternate and repetitive stacking of a first material layer of $\text{Al}_x\text{Ga}_{1-x}\text{As}$ ($0 < x \leq 1$) and a second material layer of $\text{Al}_y\text{Ga}_{1-y}\text{As}$ ($0 \leq y < x \leq 1$), wherein there is provided a hetero spike buffer layer between said first material layer and said second material layer, said hetero spike buffer layer having a refractive index intermediate between a refractive index of said first material layer and a refractive index of said second material layer, said hetero spike buffer layer having a composition represented as $\text{Al}_z\text{Ga}_{1-z}\text{As}$ ($0 \leq y < z < x \leq 1$) and a thickness of 20 - 50 nm.

15

56. An optical telecommunication system, comprising:

20 a laser diode;

a first optical fiber coupled optically to said laser diode, said first optical fiber being injected with a laser beam produced by said laser diode;

25 a second optical fiber coupled optically to

said first optical fiber, said second optical fiber being injected with an optical signal transmitted through said first optical fiber;

a third optical fiber coupled optically to
5 said second optical fiber, said third optical fiber being injected with an optical signal transmitted through said second optical fiber,

10 said laser diode comprising a surface-emission laser diode chip and comprising: an active layer of any of a layer containing Ga, In, N and As as major constituent elements thereof and a layer containing Ga, In and As as major constituent elements thereof, said active layer producing optical radiation with a laser oscillation wavelength of 1.1
15 - 1.7 μm ; and a cavity structure comprising a pair of reflectors provided above and below said active layer, each of said reflectors forming a semiconductor distributed Bragg reflector reflecting optical radiation having a wavelength of 1.1 μm or
20 more and comprising an alternate and repetitive stacking of a first material layer of $\text{Al}_x\text{Ga}_{1-x}\text{As}$ ($0 < x \leq 1$) and a second material layer of $\text{Al}_y\text{Ga}_{1-y}\text{As}$ ($0 \leq y < x \leq 1$), wherein there is provided a hetero spike buffer layer between said first material layer and said
25 second material layer, said hetero spike buffer layer

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having a refractive index intermediate between a refractive index of said first material layer and a refractive index of said second material layer, said hetero spike buffer layer having a composition
5 represented as $\text{Al}_z\text{Ga}_{1-z}\text{As}$ ($0 \leq z < x \leq 1$) and a thickness of 20 - 50 nm,

said first optical fiber having a length of 1 mm or more.

10

57. An optical telecommunication system comprising:

15 a laser diode; and
an optical transmission path coupled optically to said laser diode,

said laser diode comprising a surface-emission laser diode chip and comprising: an active
20 layer of any of a layer containing Ga, In, N and As as major constituent elements thereof and a layer containing Ga, In and As as major constituent elements thereof, said active layer producing optical radiation with a laser oscillation wavelength of 1.1
25 - 1.7 μm ; and a cavity structure comprising a pair

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of reflectors provided above and below said active layer, each of said reflectors forming a semiconductor distributed Bragg reflector reflecting optical radiation having a wavelength of $1.1\mu\text{m}$ or more and comprising an alternate and repetitive stacking of a first material layer of $\text{Al}_x\text{Ga}_{1-x}\text{As}$ ($0 < x \leq 1$) and a second material layer of $\text{Al}_y\text{Ga}_{1-y}\text{As}$ ($0 \leq y < x \leq 1$), wherein there is provided a hetero spike buffer layer between said first material layer and said second material layer, said hetero spike buffer layer having a refractive index intermediate between a refractive index of said first material layer and a refractive index of said second material layer, said hetero spike buffer layer having a composition represented as $\text{Al}_z\text{Ga}_{1-z}\text{As}$ ($0 \leq y < z < x \leq 1$) and a thickness of 20 - 50 nm,

said optical transmission path comprising an optical fiber having a length L, said optical fiber including a core having a diameter D and a clad,

wherein there holds a relationship

$$10^5 \leq L/D \leq 10^9.$$

58. An optical telecommunication system,
comprising:

a laser diode,

a mount substrate on which said laser diode
5 is mounted;

said laser diode comprising a surface-
emission laser diode chip and comprising: an active
layer of any of a layer containing Ga, In, N and As
as major constituent elements thereof and a layer
10 containing Ga, In and As as major constituent
elements thereof, said active layer producing optical
radiation with a laser oscillation wavelength of 1.1
- 1.7 μm ; and a cavity structure comprising a pair
of reflectors provided above and below said active
15 layer, each of said reflectors forming a
semiconductor distributed Bragg reflector reflecting
optical radiation having a wavelength of 1.1 μm or
more and comprising an alternate and repetitive
stacking of a first material layer of $\text{Al}_x\text{Ga}_{1-x}\text{As}$ ($0 < x$
20 ≤ 1) and a second material layer of $\text{Al}_y\text{Ga}_{1-y}\text{As}$ ($0 \leq y < x$
 ≤ 1), wherein there is provided a hetero spike buffer
layer between said first material layer and said
second material layer, said hetero spike buffer layer
having a refractive index intermediate between a
25 refractive index of said first material layer and a

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refractive index of said second material layer, said hetero spike buffer layer having a composition represented as $\text{Al}_y\text{Ga}_{1-y}\text{As}$ ($0 \leq y < z < x \leq 1$) and a thickness of 20 - 50 nm,

5 wherein a difference of linear thermal expansion coefficient between said laser diode and said substrate is within $2 \times 10^{-6}/\text{K}$.

10

59. An optical telecommunication system, comprising:

a laser diode; and

15 an optical fiber coupled optically to said laser diode,

 said laser diode comprising a surface-emission laser diode chip and comprising: an active layer of any of a layer containing Ga, In, N and As as major constituent elements thereof and a layer
20 containing Ga, In and As as major constituent elements thereof, said active layer producing optical radiation with a laser oscillation wavelength of 1.1 - 1.7 μm ; and a cavity structure comprising a pair
25 of reflectors provided above and below said active

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layer, each of said reflectors forming a semiconductor distributed Bragg reflector reflecting optical radiation having a wavelength of $1.1\mu\text{m}$ or more and comprising an alternate and repetitive

5 stacking of a first material layer of $\text{Al}_x\text{Ga}_{1-x}\text{As}$ ($0 < x \leq 1$) and a second material layer of $\text{Al}_y\text{Ga}_{1-y}\text{As}$ ($0 \leq y < x \leq 1$), wherein there is provided a hetero spike buffer layer between said first material layer and said second material layer, said hetero spike buffer layer

10 having a refractive index intermediate between a refractive index of said first material layer and a refractive index of said second material layer, said hetero spike buffer layer having a composition represented as $\text{Al}_z\text{Ga}_{1-z}\text{As}$ ($0 \leq y < z < x \leq 1$) and a

15 thickness of 20 - 50 nm,

wherein said optical fiber is mechanically connected to said laser diode in the state that said optical fiber is urged in an axial direction thereof toward a light emitting part of said laser diode.

20

60. An optical telecommunication system,

25 comprising:

a laser diode; and

one of an optical fiber and an optical waveguide coupled optically to said laser diode,

said laser diode comprising a surface-

5 emission laser diode chip and comprising: an active layer of any of a layer containing Ga, In, N and As as major constituent elements thereof and a layer containing Ga, In and As as major constituent elements thereof, said active layer producing optical

10 radiation with a laser oscillation wavelength of 1.1 - 1.7 μm ; and a cavity structure comprising a pair of reflectors provided above and below said active layer, each of said reflectors forming a semiconductor distributed Bragg reflector reflecting

15 optical radiation having a wavelength of 1.1 μm or more and comprising an alternate and repetitive stacking of a first material layer of $\text{Al}_x\text{Ga}_{1-x}\text{As}$ ($0 < x \leq 1$) and a second material layer of $\text{Al}_y\text{Ga}_{1-y}\text{As}$ ($0 \leq y < x \leq 1$), wherein there is provided a hetero spike buffer

20 layer between said first material layer and said second material layer, said hetero spike buffer layer having a refractive index intermediate between a refractive index of said first material layer and a refractive index of said second material layer, said

25 hetero spike buffer layer having a composition

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represented as $\text{Al}_z\text{Ga}_{1-z}\text{As}$ ($0 \leq y < z < x \leq 1$) and a thickness of 20 - 50 nm,

said optical fiber or said optical waveguide having a core with a diameter X, said laser diode having an aperture d and an optical emission angle θ ,

wherein there holds a relationship

$$d + 2l \tan(\theta/2) \leq X,$$

where l represents an optical path length from said laser diode to an edge of said optical fiber or optical waveguide.

15

61. An optical telecommunication system, comprising:

a laser diode; and

an optical waveguide coupled optically to said laser diode,

said laser diode comprising a surface-emission laser diode chip and comprising: an active layer of any of a layer containing Ga, In, N and As as major constituent elements thereof and a layer containing Ga, In and As as major constituent

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elements thereof, said active layer producing optical radiation with a laser oscillation wavelength of 1.1 - 1.7 μm ; and a cavity structure comprising a pair of reflectors provided above and below said active layer, each of said reflectors forming a semiconductor distributed Bragg reflector reflecting optical radiation having a wavelength of 1.1 μm or more and comprising an alternate and repetitive stacking of a first material layer of $\text{Al}_x\text{Ga}_{1-x}\text{As}$ ($0 < x \leq 1$) and a second material layer of $\text{Al}_y\text{Ga}_{1-y}\text{As}$ ($0 \leq y < x \leq 1$), wherein there is provided a hetero spike buffer layer between said first material layer and said second material layer, said hetero spike buffer layer having a refractive index intermediate between a refractive index of said first material layer and a refractive index of said second material layer, said hetero spike buffer layer having a composition represented as $\text{Al}_z\text{Ga}_{1-z}\text{As}$ ($0 \leq y < z < x \leq 1$) and a thickness of 20 - 50 nm,

wherein there holds a relationship

$$0.5 \leq F/d \leq 2$$

where d represents a diameter of a circle touching internally to an optical emission part of said laser diode and F represents a core diameter of said optical fiber.

62. An optical telecommunication system,
5 comprising:
a laser diode; and
an optical waveguide coupled optically to a
laser chip,
said laser diode comprising a surface-
10 emission laser-diode chip and comprising: an active
layer of any of a layer containing Ga, In, N and As
as major constituent elements thereof and a layer
containing Ga, In and As as major constituent
elements thereof, said active layer producing optical
15 radiation with a laser oscillation wavelength of 1.1
- 1.7 μm ; and a cavity structure comprising a pair
of reflectors provided above and below said active
layer, each of said reflectors forming a
semiconductor distributed Bragg reflector reflecting
20 optical radiation having a wavelength of 1.1 μm or
more and comprising an alternate and repetitive
stacking of a first material layer of $\text{Al}_x\text{Ga}_{1-x}\text{As}$ ($0 < x$
 ≤ 1) and a second material layer of $\text{Al}_y\text{Ga}_{1-y}\text{As}$ ($0 \leq y < x$
 ≤ 1), wherein there is provided a hetero spike buffer
25 layer between said first material layer and said

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second material layer, said hetero spike buffer layer
having a refractive index intermediate between a
refractive index of said first material layer and a
refractive index of said second material layer, said
5 hetero spike buffer layer having a composition
represented as $\text{Al}_y\text{Ga}_{1-z}\text{As}$ ($0 \leq y < z < x \leq 1$) and a
thickness of 20 - 50 nm,

said laser diode including an optical
emission part having an area S [mm^2], said laser
10 diode being driven with an operational voltage V
[volts],

wherein a parameter V/S falls in a range
from 15000 to 30000.